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THE DATA COLLECTION SYSTEM FOR FAILURE/MAINTENANCE AT THE TRITIUM SYSTEMS TEST ASSEMBLY

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ABSTRACT

A data collection system for obtaining information which can be used to help determine the reliability and availability of future fusion power plants has been installed at the Los Alamos National Laboratory's Tritium Systems Test Assembly (TSTA). Failure and maintenance data on components of TSTA's tritium systems have been collected since 1984. The focus of the data collection has been TSTA's Tritium Waste Treatment System (TWT), which has maintained high availability since it became operational in 1982. Data collection is still in progress and a total of 291 failure reports are in the data collection system at this time, 47 of which are from the TWT.

INTRODUCTION

Failure data analysis such as that described here is performed to support fusion design efforts such as the Compact Ignition Tokamak (CIT) and the International Thermonuclear Experimental Reactor (ITER). Risk and reliability analyses need the support of failure rate data to quantify results. Generally, fusion experiment failure data are not rigorously collected. At this stage in fusion research, there are more pressing demands for limited funds at experimental facilities. However, as these experiments begin to use naturally radioactive tritium fuel, government regulations for safe storage and control of tritium will apply. This creates a need for facility risk assessment to prove that the public is protected from undue radiation hazards.

TSTA became operational in 1982 for the testing and evaluation of the processes and equipment for handling the deuterium and tritium fuel and the exhaust gases from a magnetic fusion reactor.[1] TSTA is a fully-integrated, full-sized, computer-controlled fusion fuel processing loop. The main process loop and auxiliary systems are shown in Figure 1.[2]

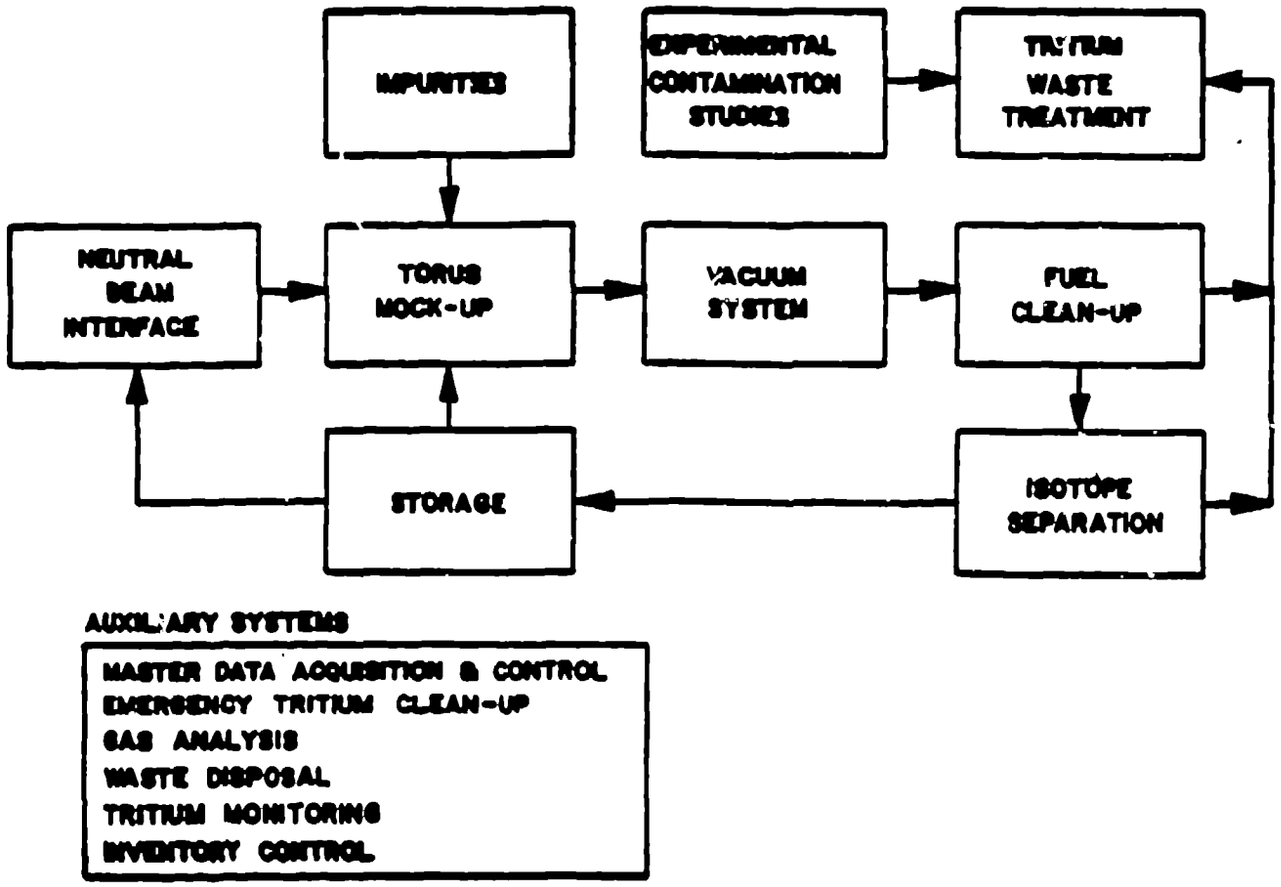

Fig. 1 TSTA main process loop and auxiliary systems.

Within the main flow loop of TSTA, gases which simulate the effluent from a magnetic fusion reactor are sent through the Vacuum System to be processed in the Fuel Cleanup Unit and the Isotope Separation System. The waste gases from loop operation and from non-loop experiments are handled by the TWT -- the effluent gas detritiation system. A flow diagram for the TWT is shown in Figure 2. The TWT is a mature technology based on similar systems that have operated for over ten years. It needs to maintain and has maintained high availability 24 hours per day, 365 days per year and it contains many components that are identical to those being used in

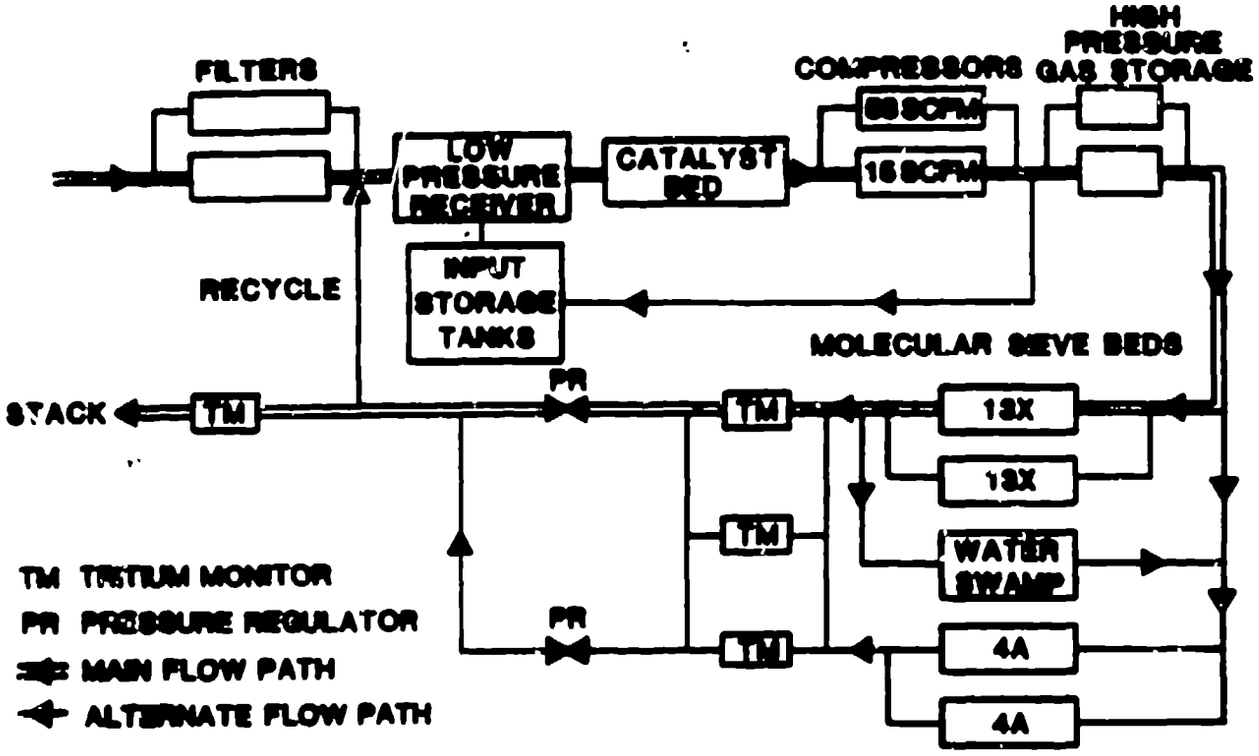

Fig. 2 Flow diagram for the Tritium Waste Treatment System

other tritium systems. Therefore, the effort of data collecting for the failure/maintenance data at TSTA has been concentrated on the TWT.

TSTA's event data collection system has been in place for 4 years and is administered by a Quality Assurance Specialist assigned to the program. A failure report form is filled out whenever a component of the TWT or a component of another TSTA system fails or needs major adjustment. A second part of the form detailing the corrective action taken is completed during or immediately after the repair/replacement of the failed component. All of this information is input to the failure/maintenance data base as it is received.

THE FAILURE/MAINTENANCE DATA BASE

The failure/maintenance data system at TSTA is based on the Centralized Reliability Data Organization (CREDO),[3] a system developed at Oak Ridge National Laboratory. CREDO's development as a national reliability data base and data analysis center for advanced fission reactors was initiated in 1978 and is funded by the U.S. Department of Energy. CREDO was

selected as the basis for a failure/maintenance data system for fusion after consideration by the informal Fusion Availability Working Group under the auspices of the U.S. DOE. It is a component-oriented data base which was implemented at TSTA using an IBM PC. The original objectives of the CREDO project at TSTA included:

- Adapting CREDO for use in fusion availability/reliability programs
- Programming the data base on the IBM PC with Knowledgeman software
- Collecting the appropriate data on the TWT and
- Testing the adapted data base with the TWT data.

Only minor changes in the original CREDO data collection forms were made to make the forms usable for fusion systems.

The IBM PC was programmed using logical tables that were set up to hold the data.[4] Three types of data are entered into the data base. They are: engineering data, event data and component data. The engineering data describes each component of a system as fully as possible by involving a one-time submission of data on a component using a unique identifying number that tracks that component through its lifetime. The event data describes each reportable event or failure in a system and uses a unique event report number. A reportable event or failure includes unscheduled repair or maintenance, necessary repair or replacement during scheduled maintenance, and any unanticipated change in normal operating conditions due to a component failure. The operating data is a quarterly report showing operating time for the entire facility. Component operating time estimates are made from these overall facility values.

After the engineering (component) data are collected on a system, event data reports become the focus of the effort for collection of failure/maintenance data. At TSTA, two-part event data forms are strategically placed in holders throughout the facility, so when a reportable event occurs, the forms can be easily accessed by the operator involved in the event. Part I of the form is filled out whenever a component of the TWT or a component of another TSTA system fails or needs major adjustment. When the initial report is completed as much as possible, it is put back into the holder. The Quality Assurance Specialist picks these up daily, assigns a sequential report number, and enters the initial data on the event into the data base, thus completing the failure data collection portion of the process. Part II of the form details the corrective action taken on the problem. This is filled out during or immediately after the repair/replacement of the failed component. Then, the Quality Assurance Specialist picks up part II of the form and enters the information into the data base. If the information on the event is complete, the failure report is termed "closed." If it is incomplete, it is termed "open" and returned to the appropriate personnel to complete.

RESULTS

Data collection has yielded a total of 291 failure reports collected over a period from January 1, 1984 to December 31, 1987. Of these reports, 47 are from the TWT system. An initial data analysis is being performed in cooperation with the Fusion Safety Program (FSP) at the Idaho National Engineering Laboratory. Table 1 gives a summary version of selected TWT failure event reports.

The failure reports for tritium monitors and motor-operated valves (MOV's) together comprise over half of the TWT reports; therefore, attention was first directed to these components for failure rate calculations. Table 2 gives the preliminary results for tritium monitor and MOV failure rates by failure mode.

As seen from Table 2, the TSTA-specific values compare closely to the cited generic failure rates[5] in some cases and poorly in others. A close comparison was not sought, only an order of magnitude estimation to a set of accepted data. The TWT valves and radiation monitors are not expected to compare closely with the generic components due to differences in design, application, and environment.

A certain variability in early reporting was noted in the TSTA data, which may lead to artificial failure rates from the small number of reports submitted and the operating time estimates. As TSTA operates longer and the data base continues to grow, stabilized failure rates with small error bounds will be attained and these values will be important to FSP accident analyses and risk assessments for future fusion facilities.

It is noteworthy that, because of appropriate redundancy and fail-safe facility design, the failures reported in Table 1 (and all other failures) have added insignificantly to environmental releases of tritium or doses to personnel at TSTA. As evidence, in 4 years of operation with large quantities of tritium, TSTA's tritium release in all forms to the environment has totaled 38 Ci and its personnel dose to all workers has totaled less than 125 person·mRem.[6] This record is far better than regulatory requirements and is excellent by any standard.

Table 1. TWT System failure data summary for MOV's and tritium monitors.

Number of TSTA reports	Component of interest	Failure Cause[a]	Component Failure Mode
2	valve	electrical failure	fail to open
3	valve CA1	unclassifiable cause	fail to open
1	valve MSA1 valve MSA4	unclassifiable cause	fail to operate as required
1	valve CA1	loose connections	fail to open
1	sampling valve	foreign material intrusion (oil)	fail to open
1	sampling valve	foreign material intrusion (dirt)	fail to open
1	valve CA1	unclassifiable cause	fail to operate as required
1	valve LPR3	unclassifiable cause	fail to close
1	tritium monitor	short circuit	incorrect reading
6	tritium monitor	unclassifiable cause	incorrect reading
1	tritium monitors (all 4 units)	unclassifiable cause	not cited
2	tritium monitor	short circuit	no reading
1	tritium monitor	broken wire	no reading

[a]causes are taken from Root Causes of Component Failures Program: Methods and Applications, NUREG/CR-4616, EGG-2455, December, 1986.

Table 2. Initial failure rates for selected TWT components (MOV's and tritium monitors) and generic failure rates.

	Component	Failure mode	Failure rate	Error bounds
I.	TSTA tritium monitor	incorrect reading	5.1×10^{-5}/hour	1.1,1.1a
		no reading	2.2×10^{-5}/hour	1.4,1.6
	IEEE Std 500 ion chamber[b]	all modes	3.87×10^{-6}/hour	1.5,1.7
II.	TSTA motor operated valve	fail to open	1.0×10^{-4}/demand	1.3,1.4
		fail to operate	3.9×10^{-5}/demand	2.0,3.0
	IEEE Std 500 motor operated valve[c]	fail to open	2.5×10^{-6}/demand	5,2
		fail to operate as required	1.0×10^{-5}/demand	5,2

[a]the first listed error bound is the upper limit failure rate divided by the given point estimate rate. The second listed error bound is the result of the point estimate failure rate divided by the lower bound failure rate.

[b]IEEE Std-500, page 611.

[c]IEEE Std-500, page 431.

CONCLUSIONS

Since initiation of this failure data collection program in 1984, much progress has been made. The system is now working well by cooperation of the Quality Assurance Specialist and the operations staff. Useful data are being collected and stored in a retrievable and searchable computer format, and plans for the future include expanding the system as resources permit to include Emergency Tritium Cleanup System component data.

The data collected is valuable both to the Tritium Systems Test Assembly and to the fusion community. Internally, a good tracking system for component failures promotes better facility operation. Identification of recurring trouble areas for special attention and insights to "generic" component problems all support increased facility availability and safety. These advantages aid the operations staff.

The fusion community benefits from the TSTA data collection program in the form of support for accident analysis and risk assessment quantification, and initiating event selection.

The TSTA data will be useful for the CIT Preliminary Safety Analysis Report and perhaps for ITER. Other scientific research facilities that deal with tritium can also benefit from this type of information.

TSTA management views the release of failure reports as a basic output of its work and a contribution to the fusion community. Plans call for continuation of this work until sharing failure data is no longer productive.

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